

# **Fuel Cell Vehicles**

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# **What are Fuel Cells?**

**Electrochemical energy conversion device**

**Produces electricity, water, and heat by the combination of hydrogen and oxygen**

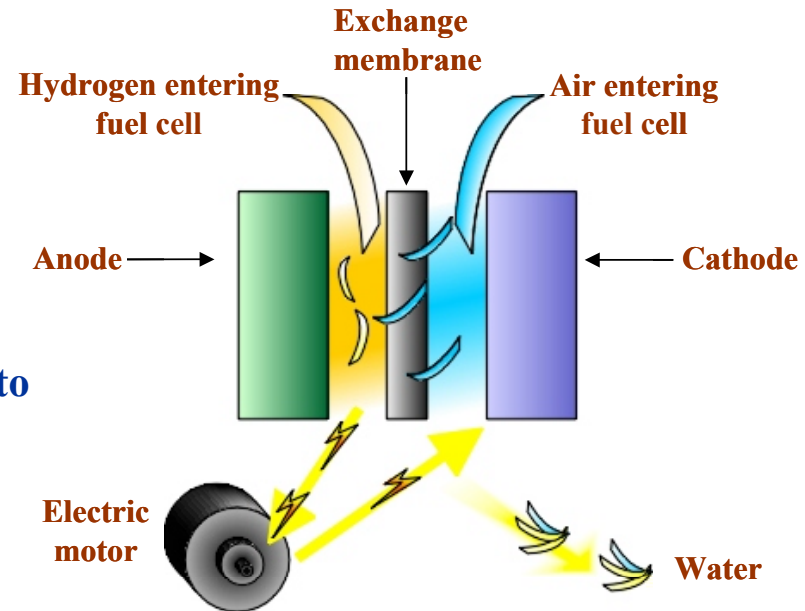
**Two to three times more efficient than an internal combustion engine**

# How a Fuel Cell Works

**Anode (-)** a platinum catalyst helps the separation of hydrogen gas into electrons and hydrogen ions

**Membrane** hydrogen ions pass through the membrane, the electrons flow through an external circuit producing electricity

**Cathode (+)** a platinum catalyst helps the hydrogen ions, oxygen, and the electrons combine to form water



# Infrastructure

# Hydrogen Production

## Steam Reformation of Hydrocarbon Fuel

Separating carbon and hydrogen

Forms  $\text{H}_2$  and  $\text{CO}_2$

Least expensive

## Electrolysis

Electric current passes through water to produce

$\text{H}_2$  and  $\text{O}_2$

Expensive

Potential for zero emissions and sustainable production

# **Hydrogen Storage**

## **On Board Storage**

**Compressed Hydrogen Gas**

**Liquefied Hydrogen**

**Hydrogen Absorbed on a Metal Hydride**

**Zero emissions**

## **On Board Production with a Reformer**

**Hydrocarbon Based Fuel**

**Methanol**

**Some emissions**

# **Direct Methanol Fuel Cell**

**No reformer needed to generate hydrogen**

**Methanol is injected directly into the fuel cell**

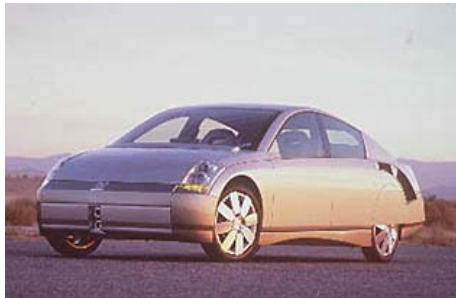
**Methanol reacts to form electricity and CO<sub>2</sub>**



**Ballard Buses**



**Ford Prodigy**



**GM Precept  
Demo 2004**

# Fuel Cell Vehicles



**Chrysler**



**Jeep**

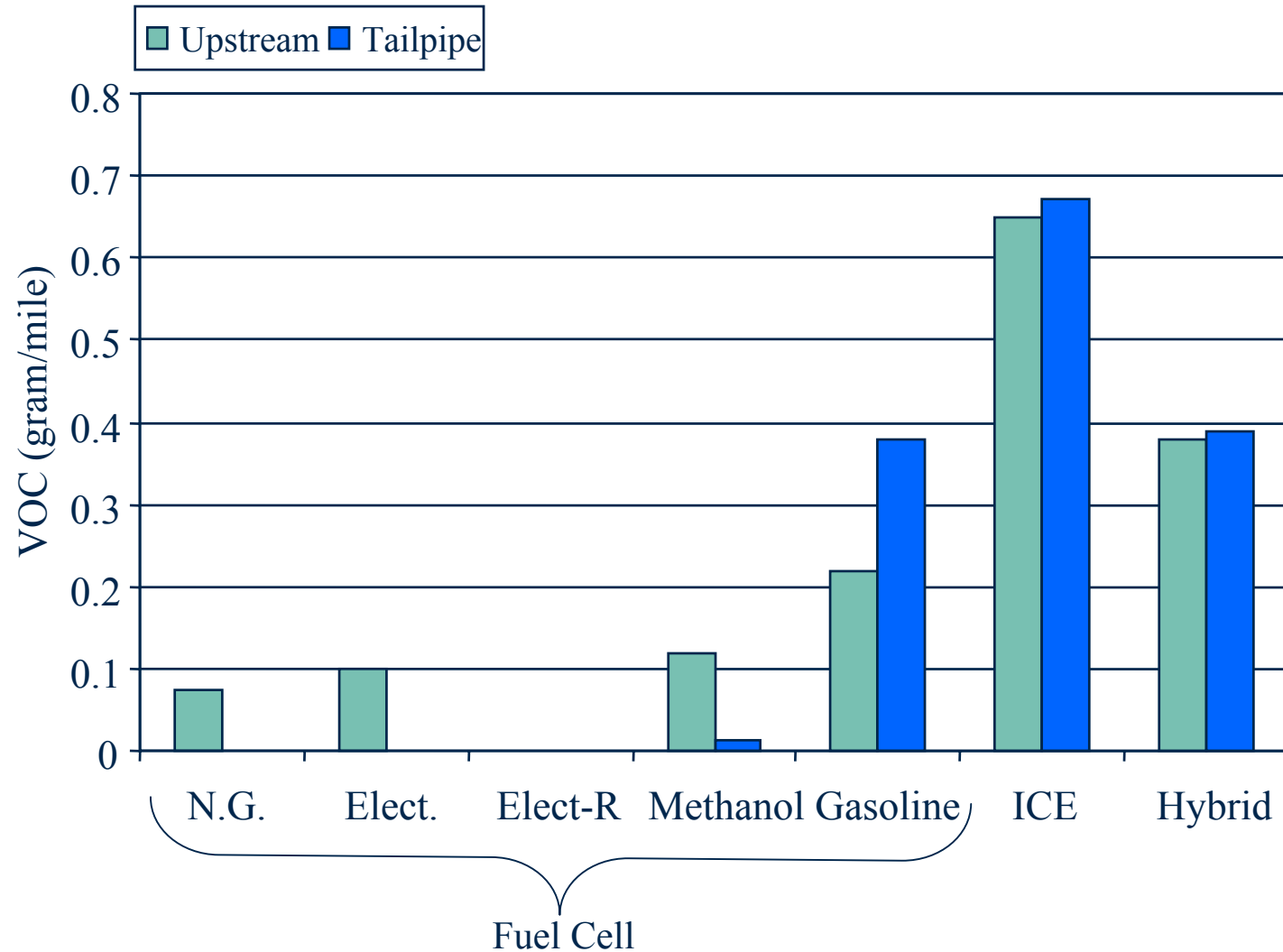


**GM Opel Zafira**

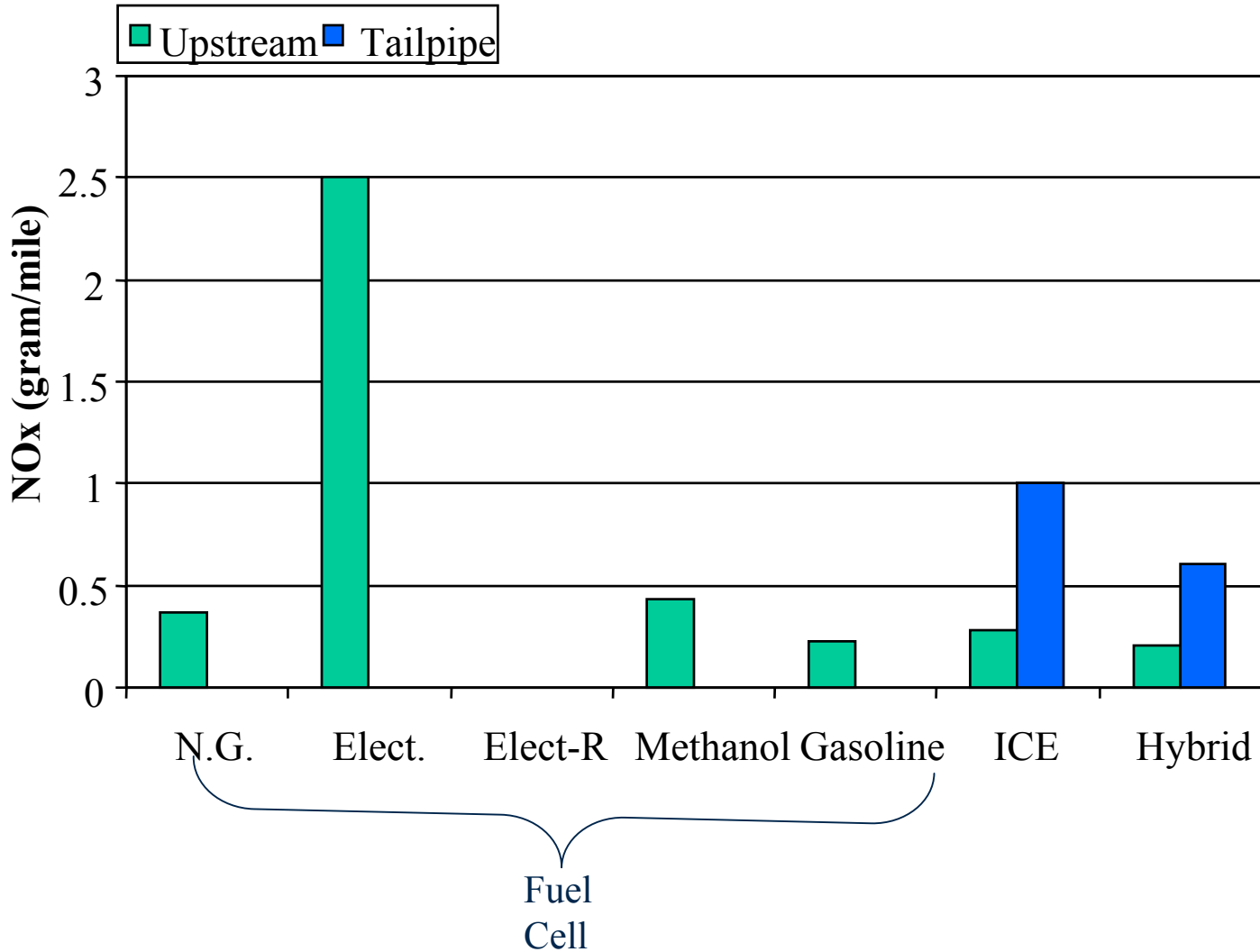


# **Fuel Cell Air Quality Impacts**

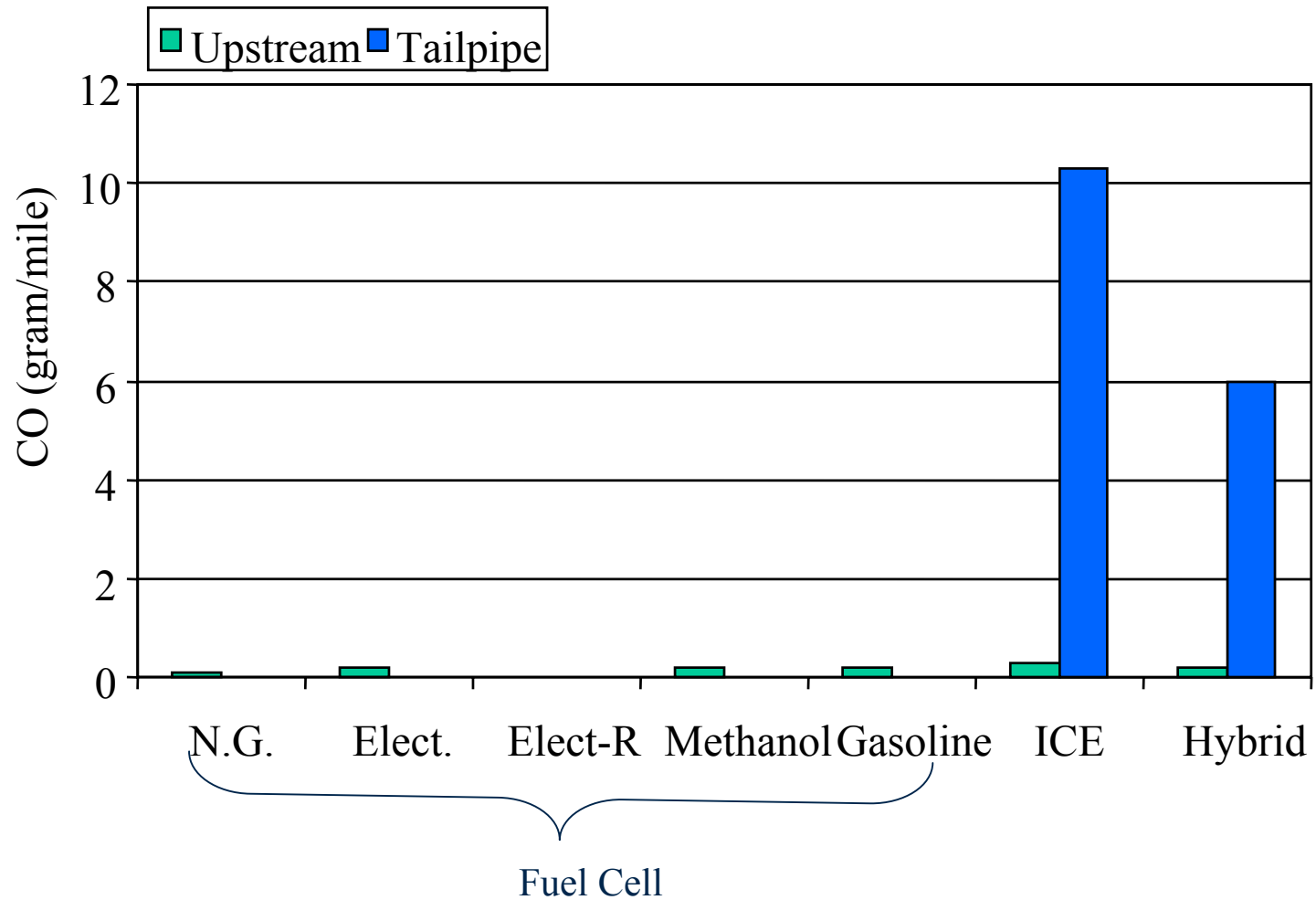
# VOC Emissions



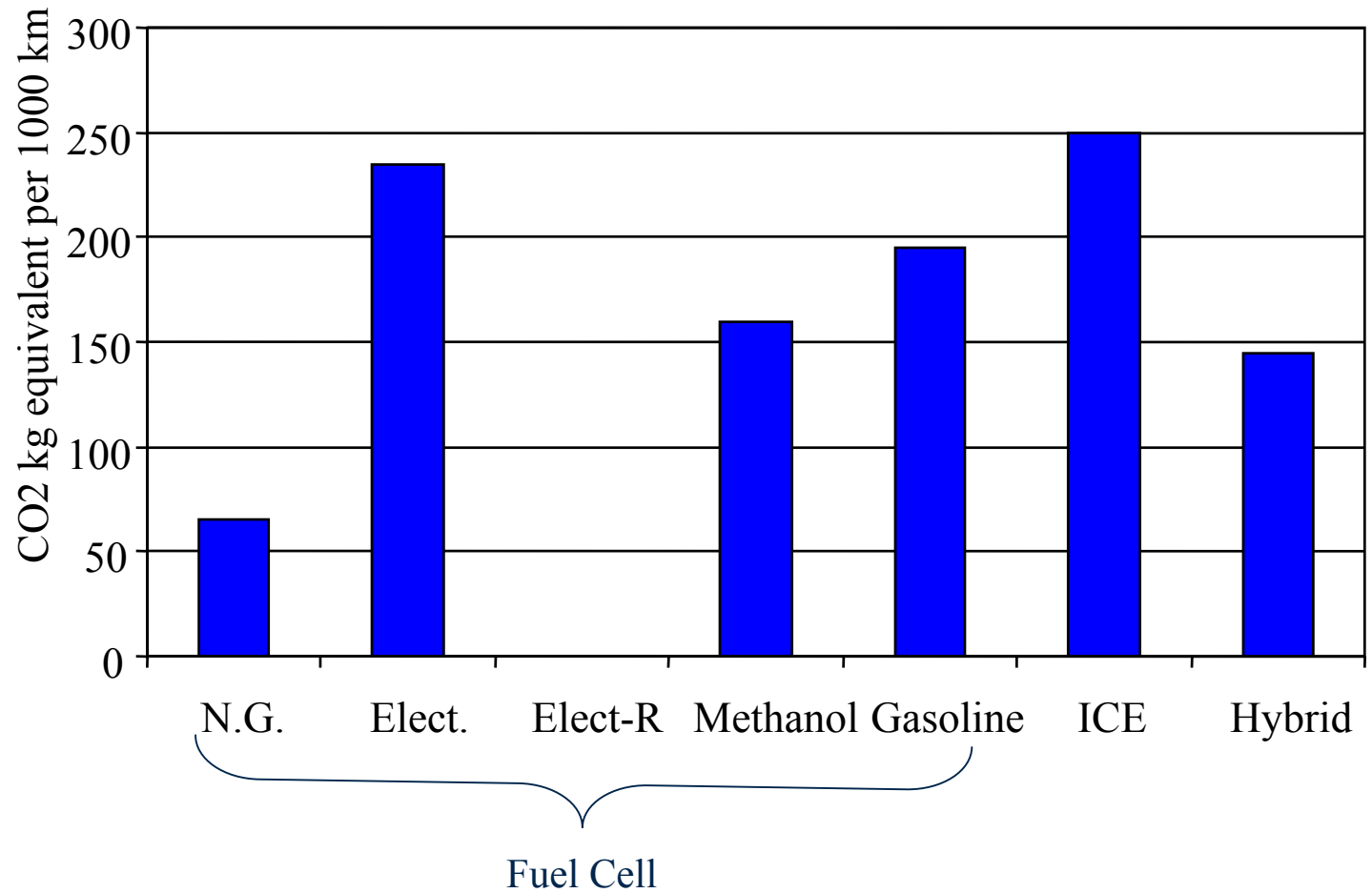
# NO<sub>x</sub> Emissions



# CO Emissions

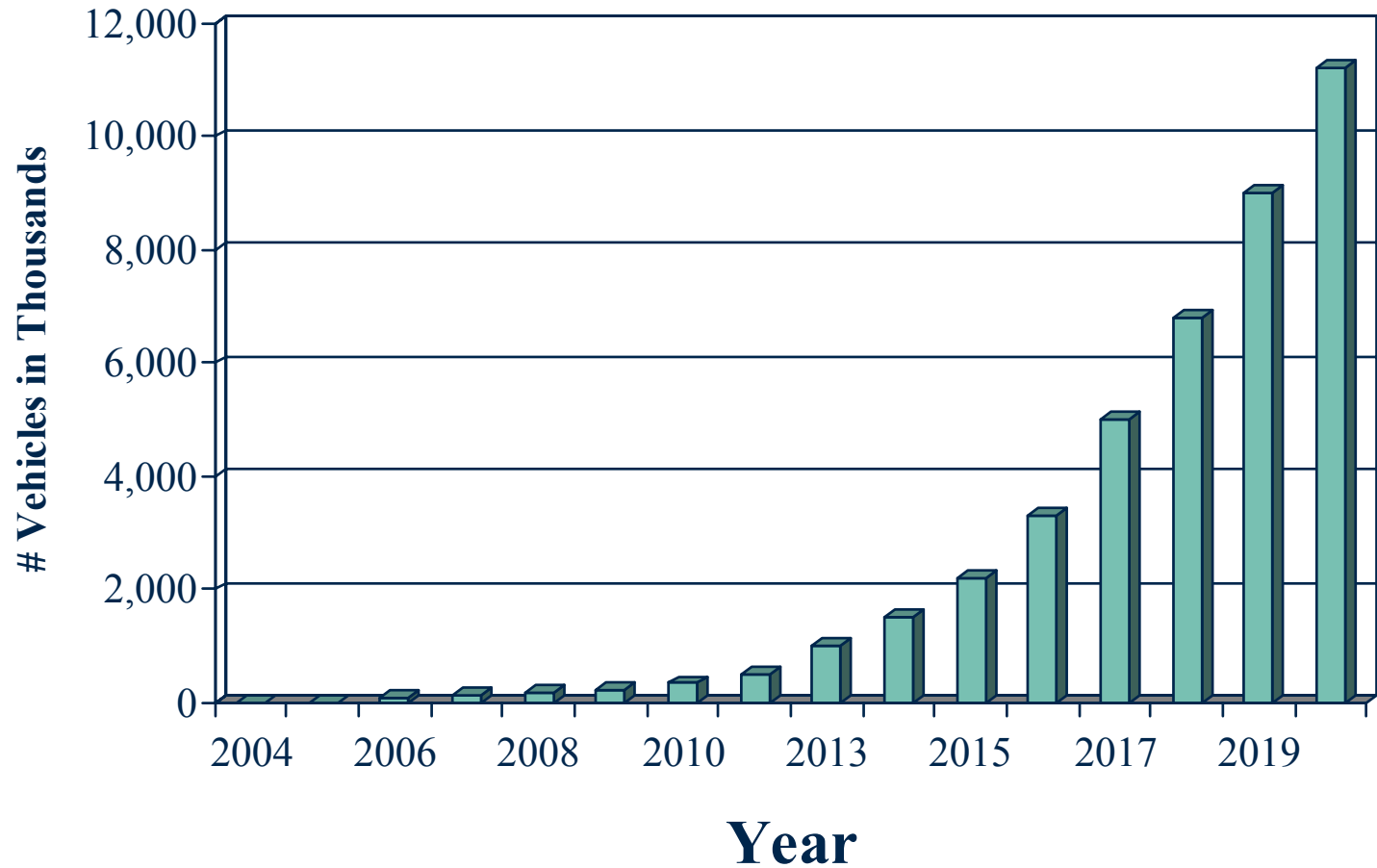


# GHG Emissions



# **Fuel Cell Future ??**

## ■ Fuel Cell Vehicle Sales



Based on estimates from: DOE and the Japanese Institute of Energy Economics

# THANK YOU !!!

Robert Kosak  
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